



# **Armed Forces College of Medicine AFCM**



# **Cardiac Output**

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## INTENDED LEARNING OBJECTIVES (ILO)



By the end of this lecture the students will be able to:

- 1) Define stroke volume, cardiac output, and cardiac index
- 2) Explain the influence of altered preload on force of contraction of the cardiac muscle.
- 3) Describe the factors that help in venous return in upright position
- 4) Explain the role of contractility and after load in regulation cardiac output.
- 5) Describe the Indices of myocardial contractility

# Cardiac Output



## Definition:

- ✓ **Cardiac output is the amount of blood pumped from each ventricle in one minute.**
- ✓ **It equals 5 L/min in adult healthy man in supine position.**



# Do cardiac output vary?



## Yes it vary with

1. The basic level of body metabolism.
2. The level of activity of the body.
3. Exercise
4. Age
5. The body size.
6. Pregnancy
7. Body position standing or sitting.

## Some Important Definitions



### Stroke Volume:

It is the amount of blood pumped by the ventricle in one beat.

### End Diastolic volume:

It is the amount of blood present in each ventricle at the end of diastole.

### End Systolic volume:

It is the amount of blood remaining in each ventricle at the end of systole.

### Cardiac Index :

The cardiac index is the cardiac output per square meter of body surface area.

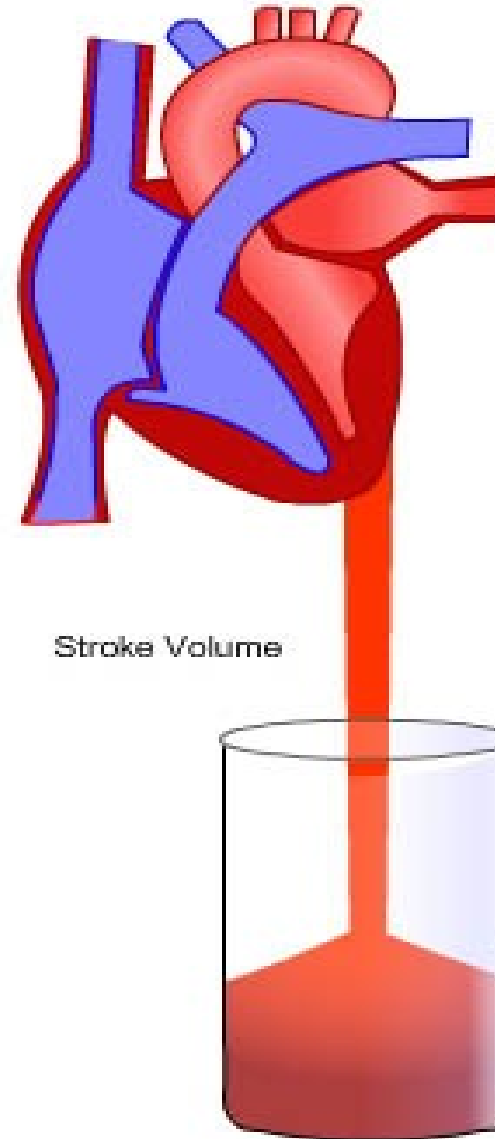
### Ejection Fraction:

It is the ratio of stroke volume to end diastolic volume. It averages 60%.

# Cardiac Output



**Cardiac output =  
Stroke volume ×  
Heart rate**

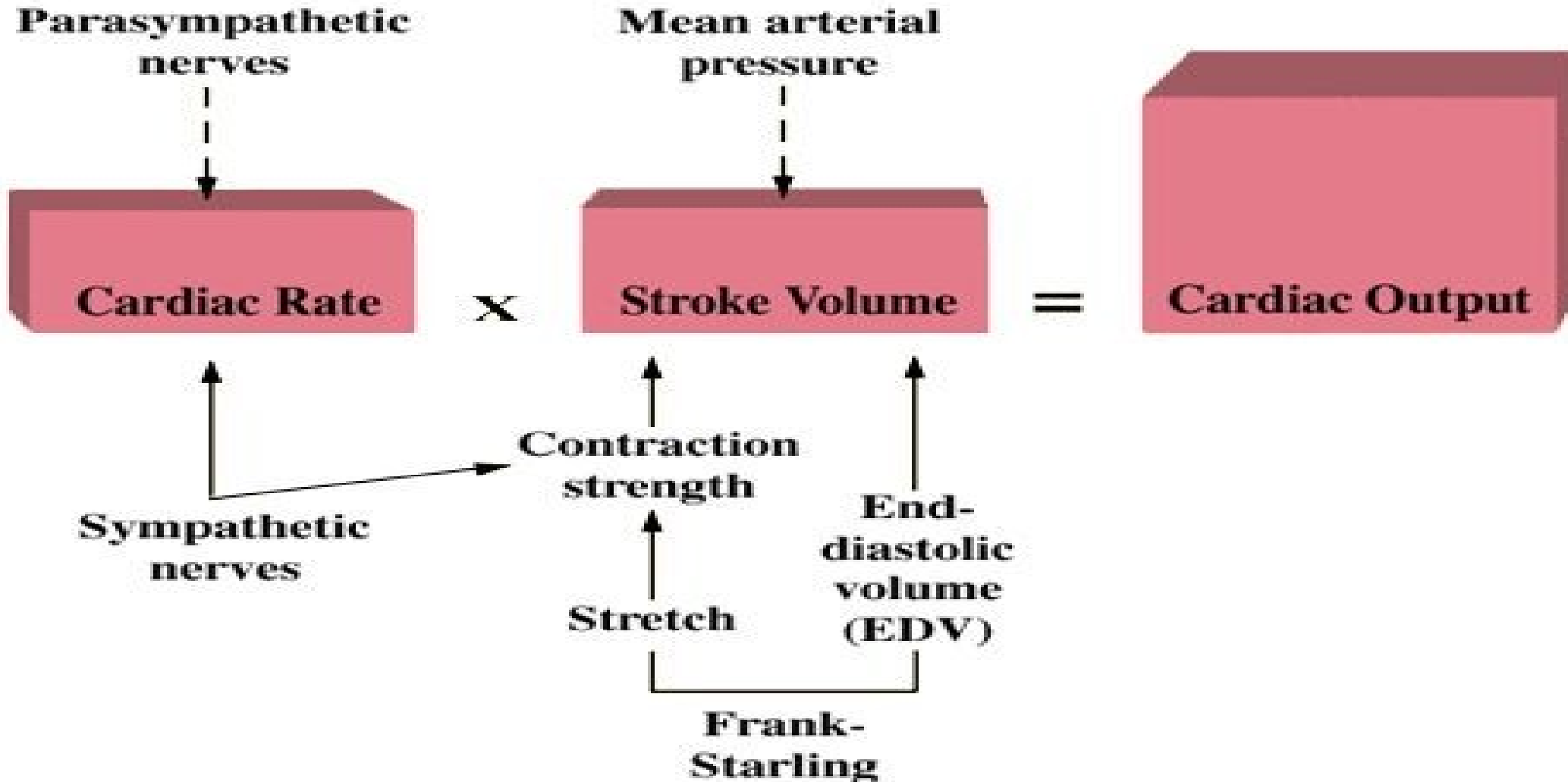


To increase cardiac output

Increase stroke volume  
or

Increase heart rate  
or  
increase both

# Cardiac Output Determinants



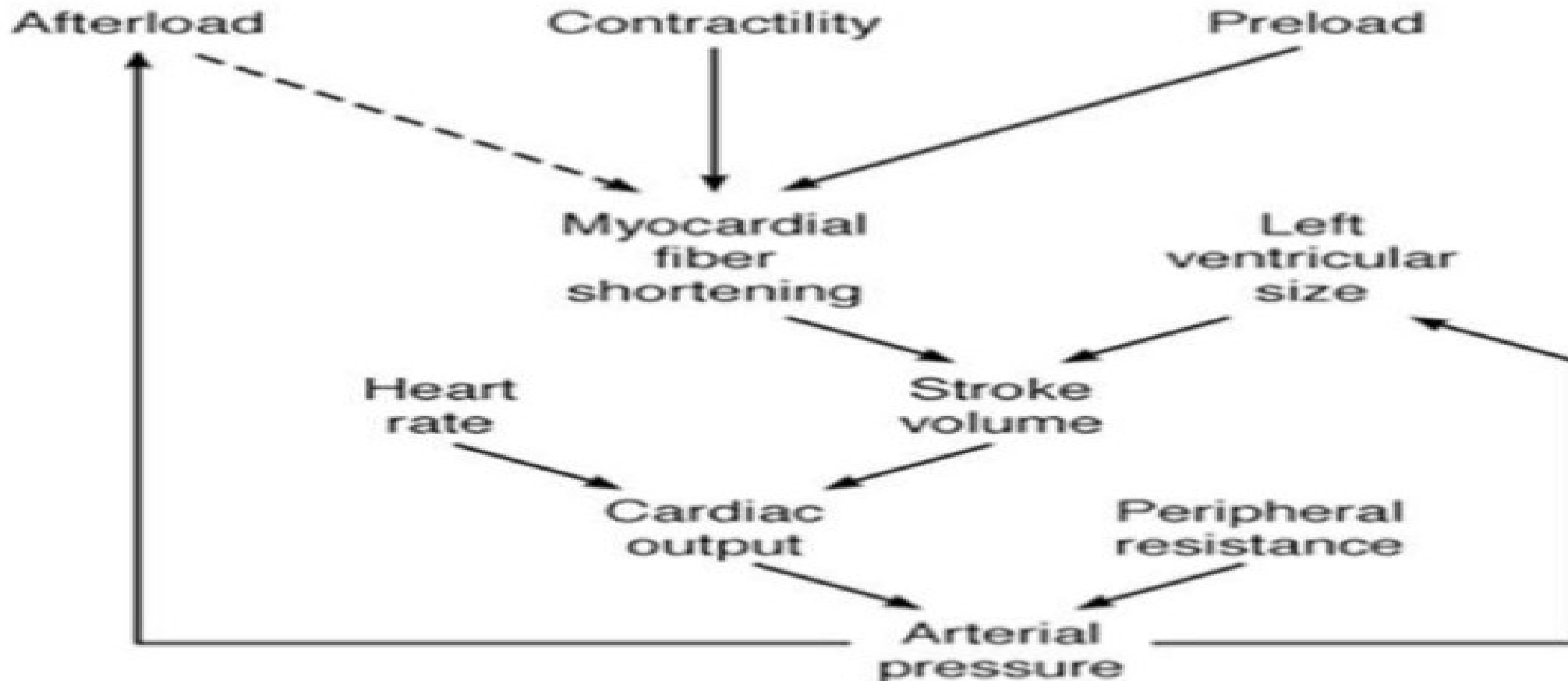
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# Factors regulating cardiac output



## Factors regulating Cardiac Output



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# 1) End Diastolic Volume

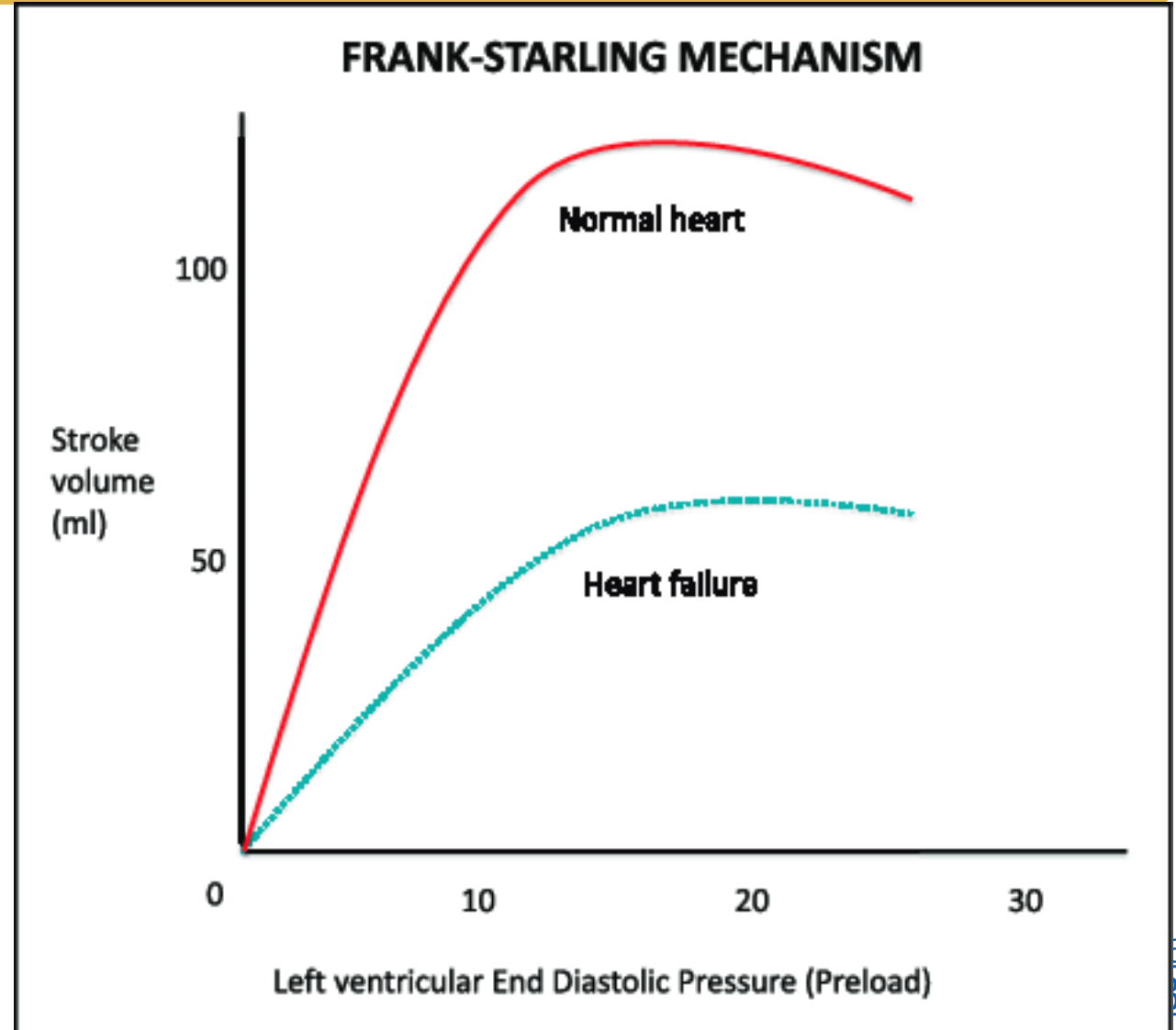


**EDV= Preload, venous return, Heterometric regulation):**

**Stroke volume is increased with increased EDV due to:**

**Frank- Starling's law ??????**

**The length of the muscle fibers is proportional to the end-diastolic volume.**



# End Diastolic Volume



**End diastolic volume is affected by :**

- 1. Venous return**
- 2. Systolic contractions of the ventricle**
- 3. Diastolic functions as increase in intrapericardial ...**
- 4. The total blood volume (Direct relationship): .....**

# Factors helping venous return



**Capillary  
Tone**

**End-diastolic volume**

**Valves of the  
vein**

**Venous return**

**Negative  
intrathoracic  
pressure**

**Venous pressure**

**Breathing**

**Blood volume**

**Urine  
volume**

**Tissue-fluid  
volume**

**Venoconstriction**

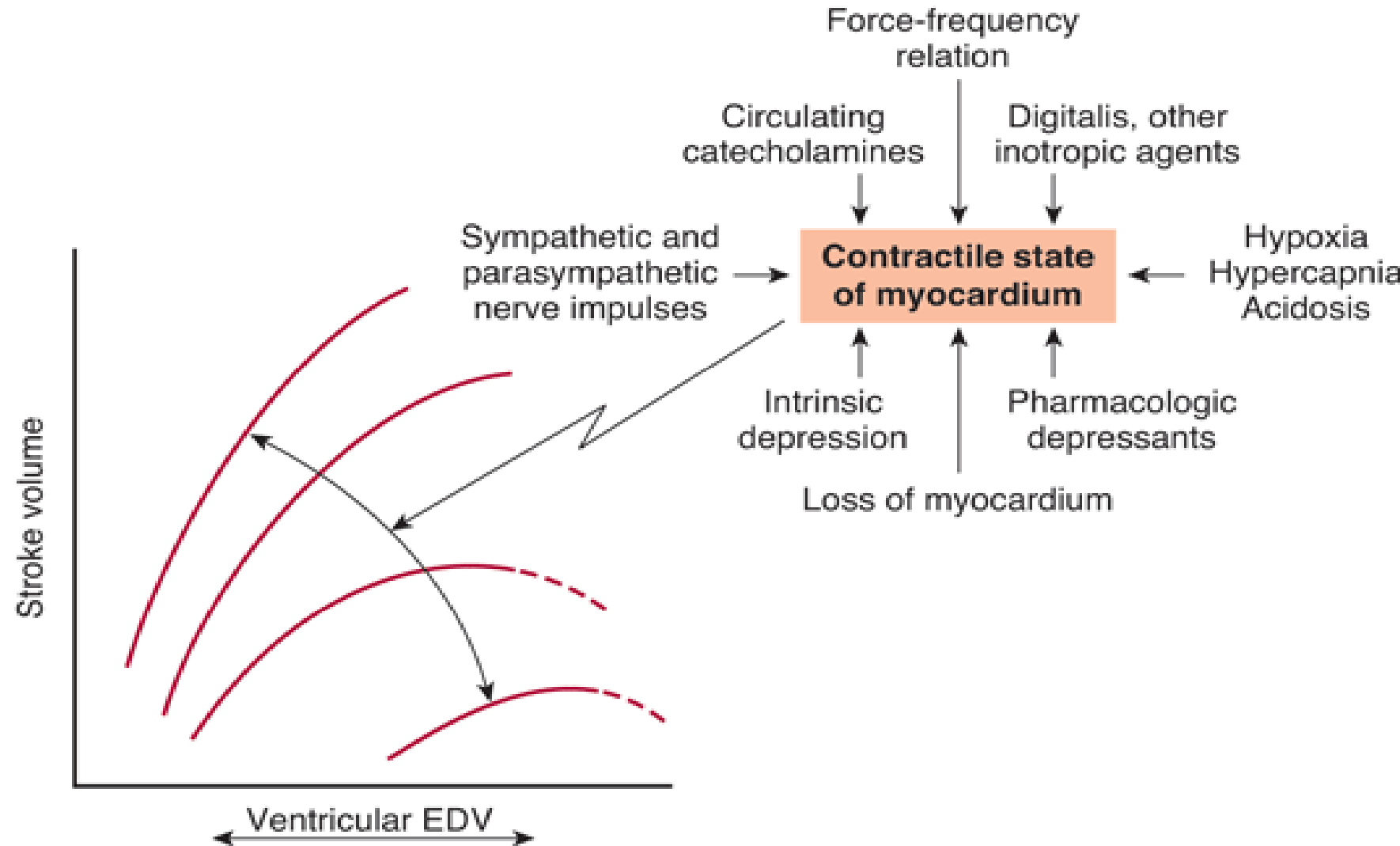
**Skeletal  
muscle  
pump**

**Sympathetic  
nerve stimulation**

## 2) Myocardial Contractility



Regulation due to changes in contractility independent of length is sometimes called **homomeric regulation**.



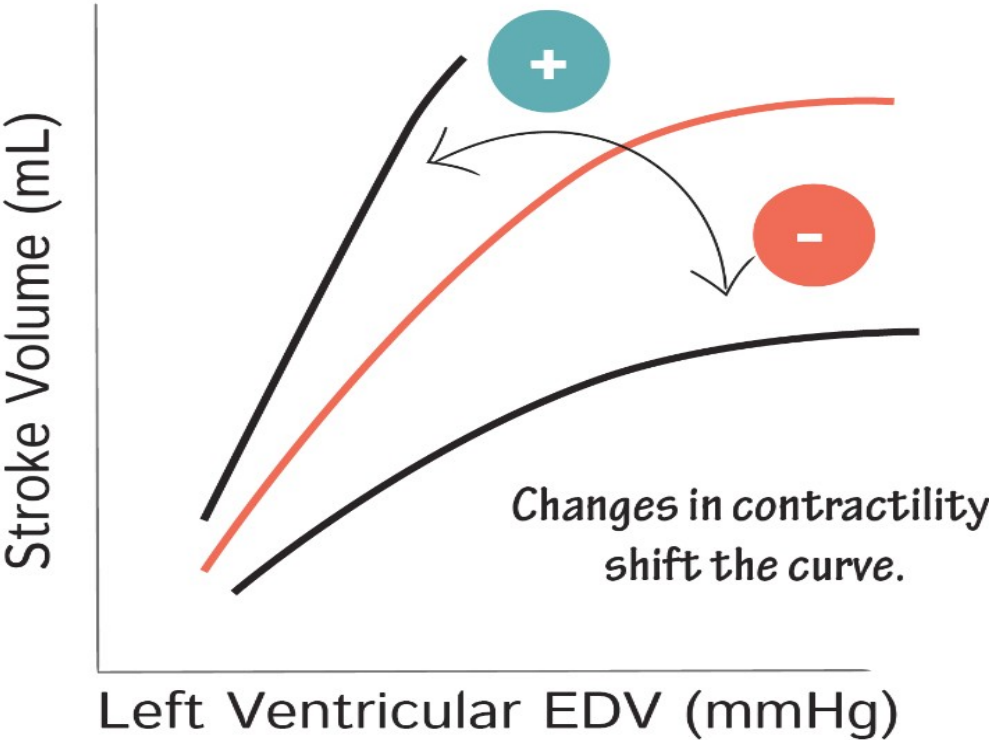
Source: Barrett KE, Barman SM, Boitano S, Brooks H: *Ganong's Review of Medical Physiology, 23rd Edition*: <http://www.accessmedicine.com>

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# Factors affecting contractility



## Frank-Starling Law



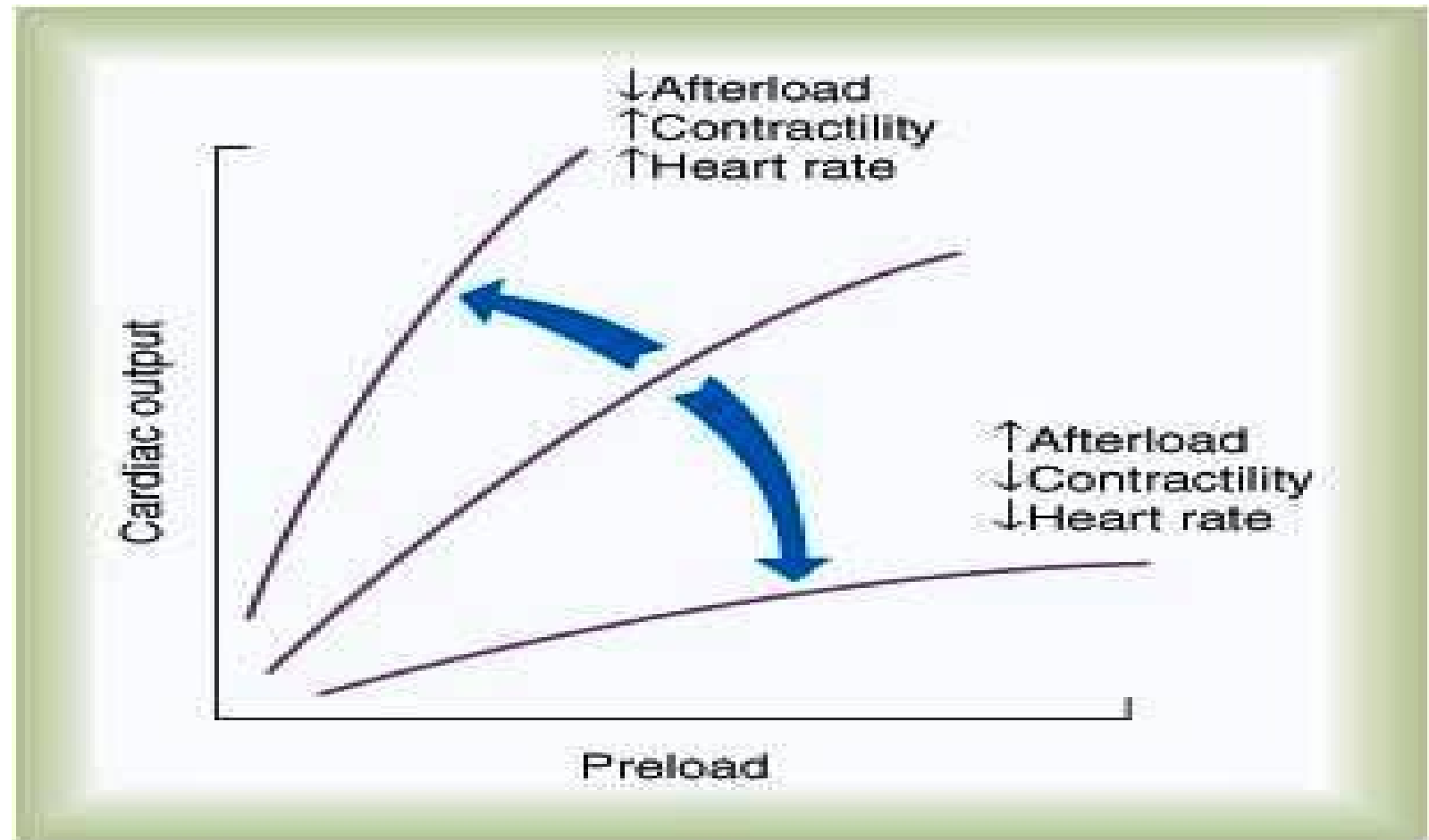
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+ve inotropic factors	-ve inotropic factors
The sympathetic nervous system ( $\beta 1$ )	The parasympathetic nervous system (M2)
Circulating catecholamines ( $\beta 1$ )	Intrinsic depression (heart failure)
Digitalis (inhibition of $\text{Na}^+ - \text{K}^+$ pump).	Loss of myocardium
Increased heart rate due to increased	Hypoxia and acidosis

### 3) Peripheral resistance



**The cardiac output has reciprocal relationship with changes in total peripheral resistance**



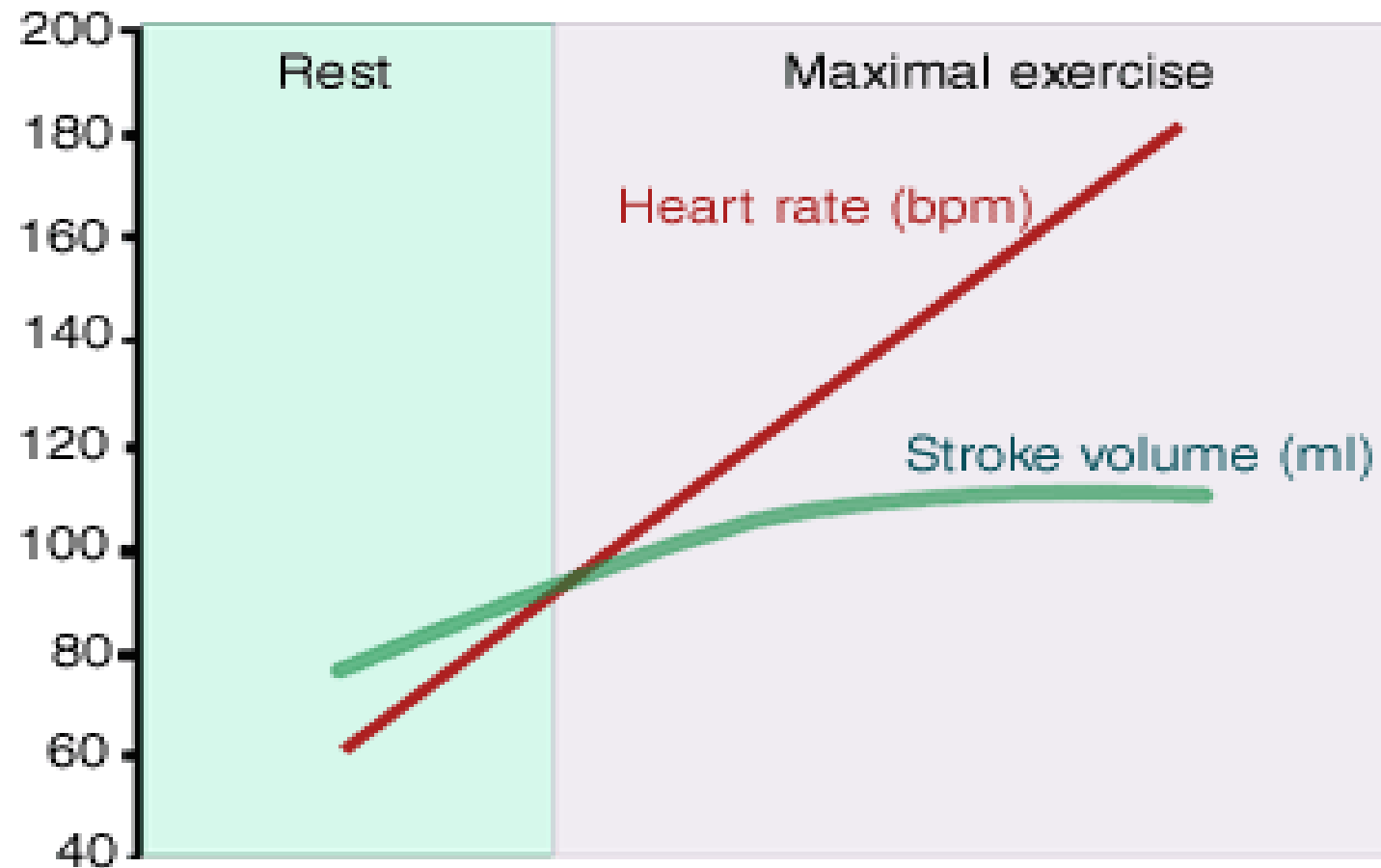
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## 4) Heart rate



**Heart rate  
has direct  
proportion  
to cardiac  
output**

**What  
happen  
with **Very  
rapid heart  
rate** ?**



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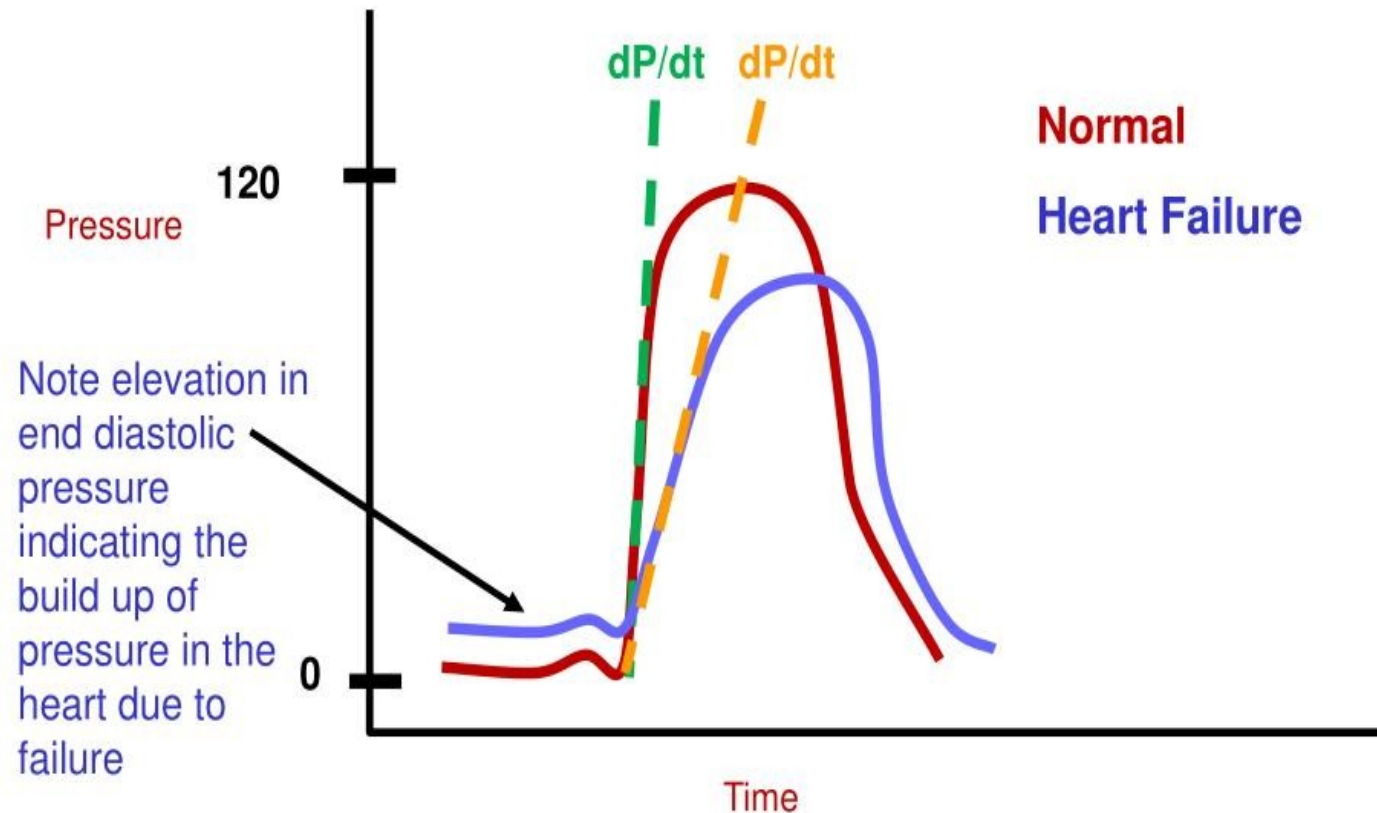


# Indices of Contractility



## dp/dt

$dp/dt$  = change in pressure per unit of time



## Ejection Fraction

Parameter	Males	Females
LVEF (%)	55-73	54-74
EDV (mL)	102-235	96-174
ESV (mL)	29-93	27-71
SV (mL)	66-148	62-110

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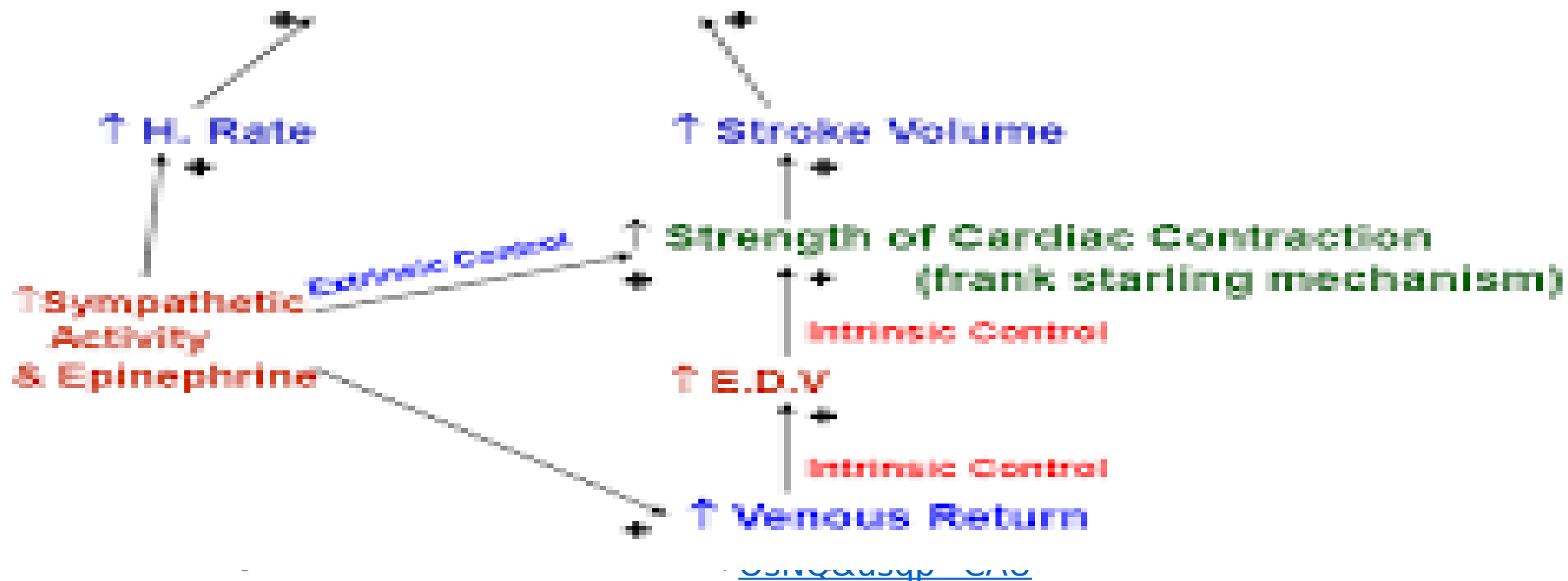
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# Regulation of Cardiac Output

↑ Cardiac Output

$$C.O = H.R \times S.V$$

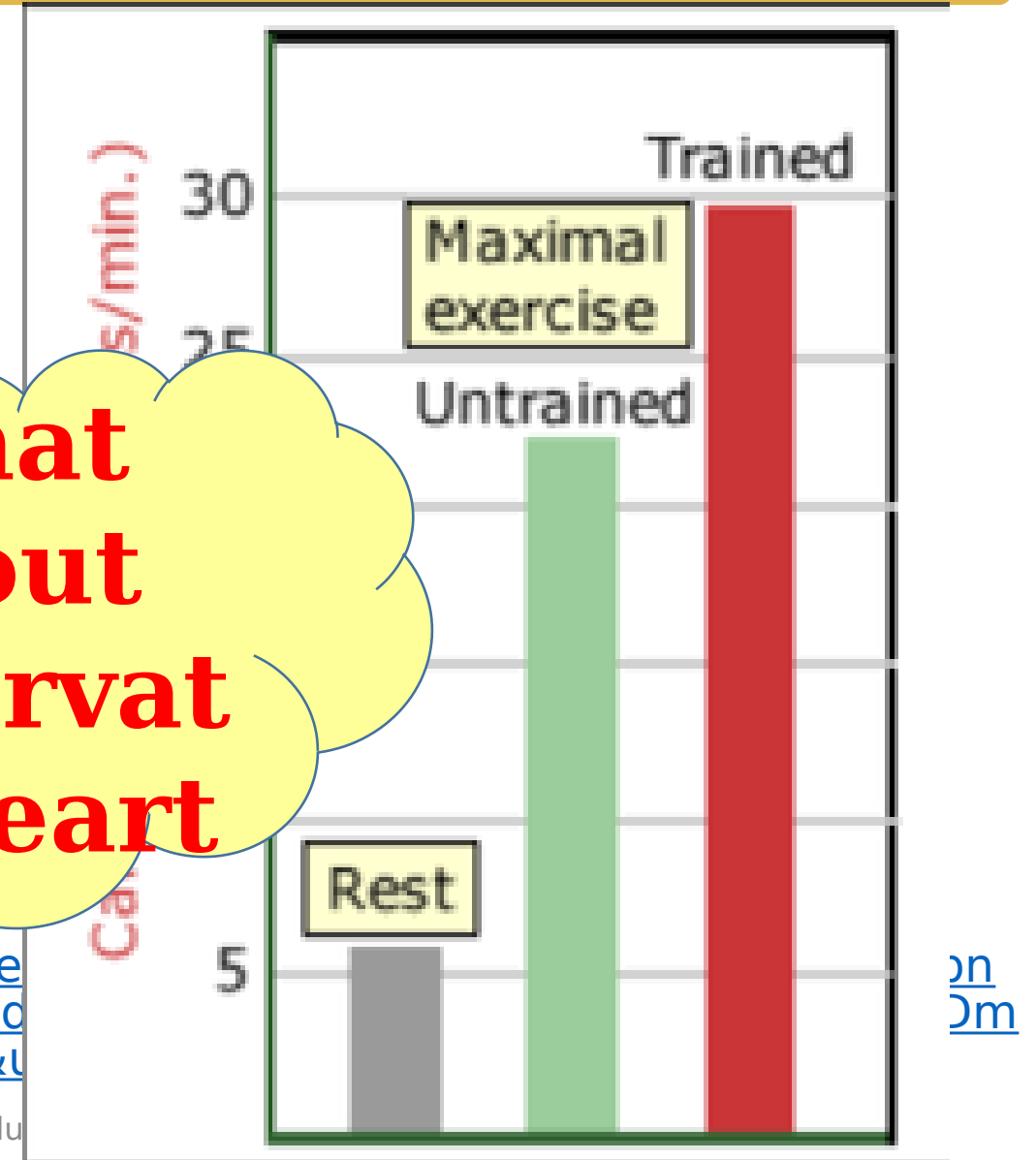


# Cardiac Output in Exercise



- During exercise sympathetic stimulation increase .....
- circulating catecholamines????
- Muscle contraction during exercise and increase respiratory rate increase venous return, end diastolic volume and CO.
- Due to vasodilation of skeletal muscle blood vessels, peripheral

What about denervated heart

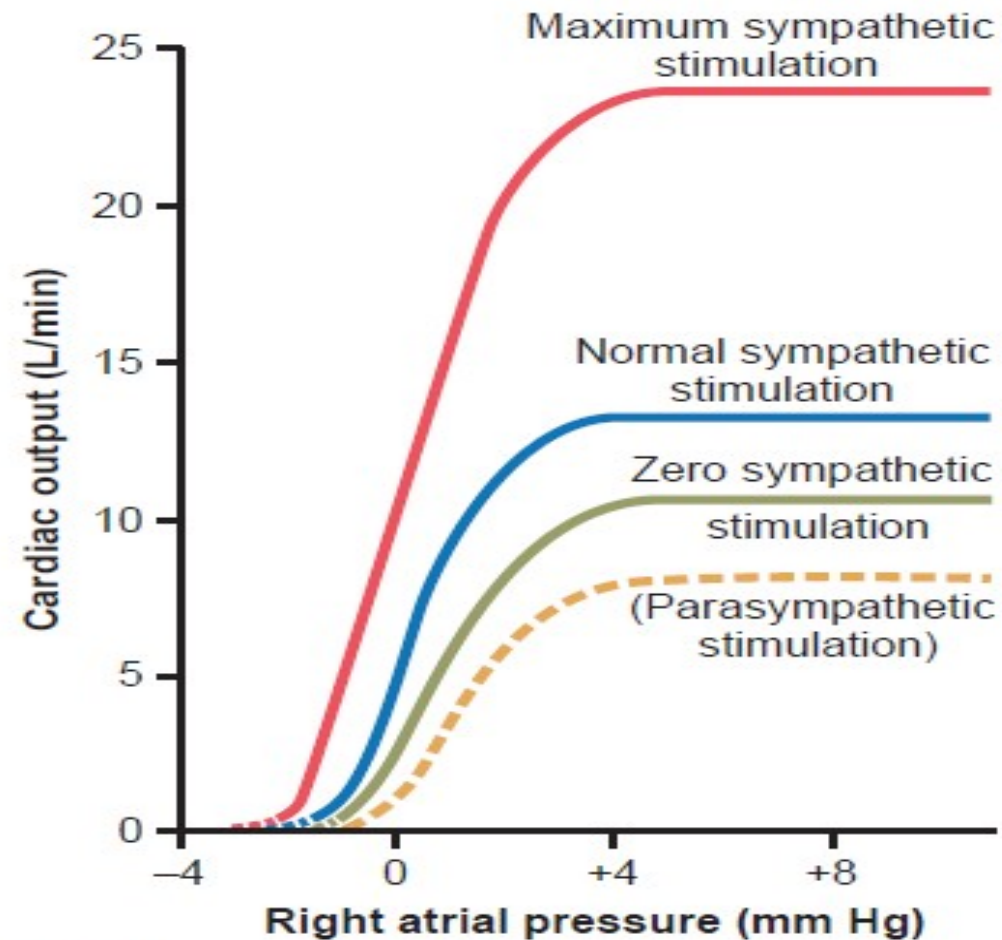


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# Cardiac output and sympathetic stimulation



- Decrease **systolic interval** by increasing contractility and increased peak ventricular pressure.
- Decrease **diastolic interval** by increasing heart rate: as intracellular calcium is increased more than sequestered calcium. So contractility increase



# Lecture Quiz



Q1) Determinants of cardiac output are ?

a) Stroke volume

b) Heart rate

Q2) which of the following will not increase CO in exercise:

a) Frank starling law .

b) Increased heart rate

c) Increased venous return

d) Venodilation

e) Sympathetic stimulation

**d**

## SUGGESTED TEXTBOOKS



1. Ganong 23<sup>rd</sup> edition P 678 to P. 685
2. Guyton and Hall 13<sup>th</sup> edition P. 118. to P. 120



# Thank you



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